Tanja Sekulić [27]
Technical College of Applied Sciences in Zrenjanin, Zrenjanin/Serbia
Dušan Malić [28]
Technical College of Applied Sciences in Zrenjanin, Zrenjanin/Serbia
Aleksandar Rajić [29]
Technical College of Applied Sciences in Zrenjanin, Zrenjanin/Serbia

REPURPOSING WASTE FOR SUSTAINABLE ENERGY: A SOLAR COLLECTOR MADE FROM RECYCLED ALUMINUM CANS

DOI: 10.5937/PIM25123S

Abstract:
The increasing demand for sustainable energy solutions has driven the development of innovative methods for harnessing renewable energy. This paper presents the design, construction, and implementation of a cost-effective solar air collector made from recycled aluminum cans. By utilizing readily available, low-cost materials, this system offers an accessible and eco-friendly approach to improving energy efficiency. Its construction requires only basic tools and skills, making it feasible for individuals, households, and small communities to build and install their own solar collectors. This approach not only reduces waste by repurposing aluminum cans but also helps lower heating costs, particularly in colder climates. The system effectively raises air temperature, providing a practical solution for supplemental space heating. The primary goal of this paper is to demonstrate the potential of Do-it-yourself (DIY) solar collectors as an affordable, scalable technology for enhancing energy efficiency while promoting environmental sustainability.

Keywords: *Solar collector, Energy efficiency, Recycled aluminum cans*

Introduction

Climate change poses a significant challenge to global energy security and environmental sustainability. The reliance on fossil fuels contributes to greenhouse gas emissions, amplyfuing global warming and environmental degradation [1]. One way to mitigate these effects is by adopting renewable energy technologies that reduce carbon footprints and enhance energy efficiency.

[27] tsekulicvts@gmail.com, ORCiD: 0000-0002-0977-4964
[28] dusan.malic@outlook.com, ORCiD: 0009-0002-1846-4228
[29] aleksandar.rajic@vts-zr.edu.rs, ORCiD: 0000-0003-3921-1502

Engineering plays a crucial role in developing sustainable solutions by repurposing waste materials into functional energy systems. The concept of circular economy promotes waste minimization by finding alternative uses for discarded materials [2]. One such approach is the construction of solar air collectors from recycled aluminum cans, which integrates both renewable energy utilization and waste management.

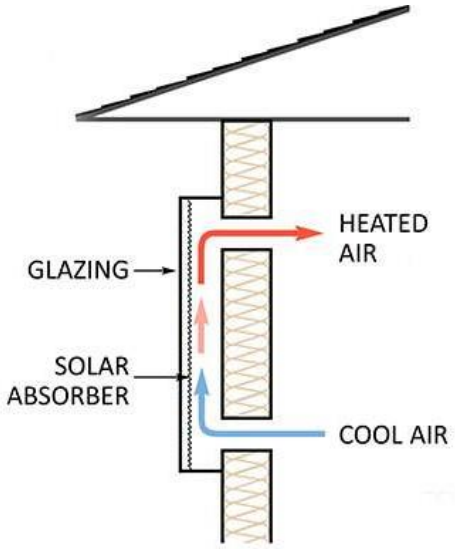
This paper explores the feasibility of repurposing aluminum cans to construct an efficient solar air heating system. By leveraging simple design principles and low-cost materials, this innovation can be implemented at various scales, providing a sustainable heating solution while reducing waste.

1. Principles of Solar Air Heating

Solar air heating is a technology that utilizes solar radiation to increase the temperature of air, which can then be used for space heating or other applications [3].

The basic principles governing the performance of a solar air collector include, Picture 1:

- Absorption of Solar Energy: The collector absorbs solar radiation, converting it into heat energy.
- Heat Transfer to Air: Air is circulated through the system, gaining heat as it passes over the heated surface.
- Convection and Insulation: The efficiency of the system depends on minimizing heat losses and maximizing airflow through the collector.



Picture 1. *The performance of a solar air collector*

Recycled aluminum cans serve as an effective medium for heat transfer due to their high thermal conductivity. When arranged in a column and painted black, they enhance solar absorption and facilitate air heating within the system.

Factors affecting efficiency include the design of the airflow path, the insulation used, and the orientation of the collector relative to the sun. Properly optimizing these factors can significantly improve heating performance.

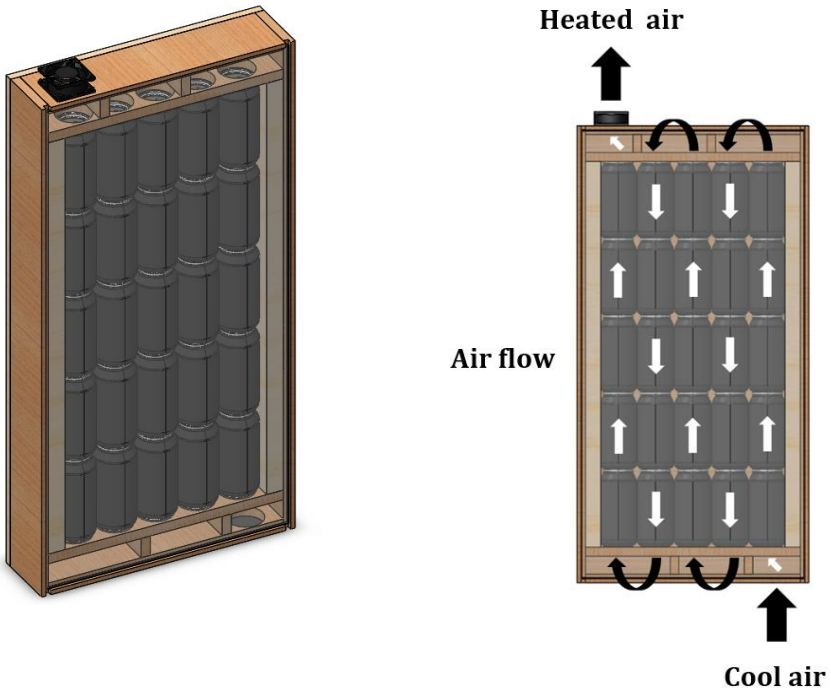
2. Design and Functionality of the Recycled Aluminum Can Solar Air Collector

The solar air collector is designed to harness solar energy efficiently while utilizing recycled materials. The main components include:

1. Aluminum Can Columns: Act as heat exchangers, allowing air to flow through and absorb heat.
2. Plexiglass or Polycarbonate Cover: Traps solar radiation, creating a greenhouse effect to increase efficiency.
3. Wooden or Metal Frame: Provides structural support for the collector.

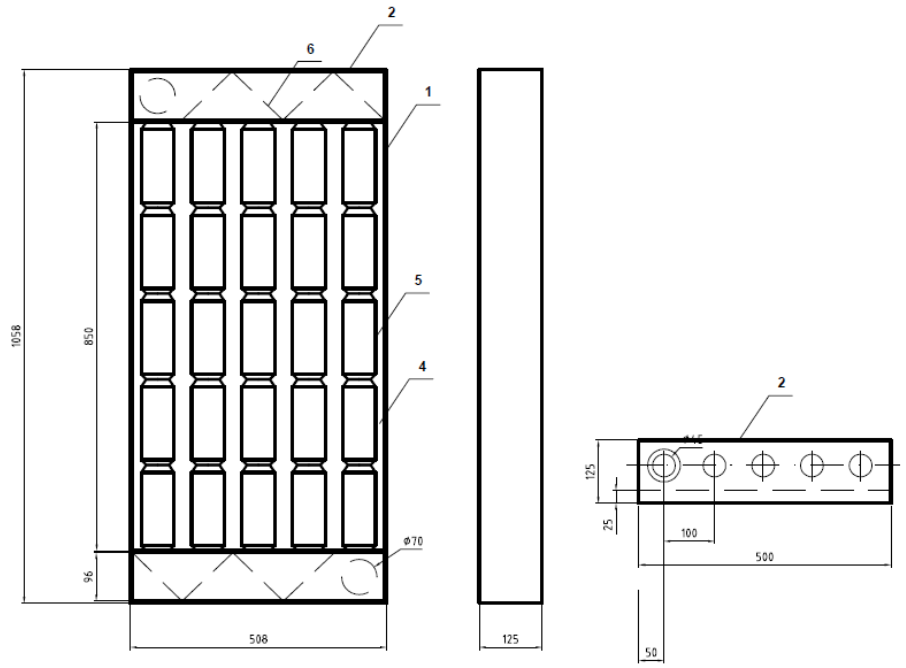
4. Insulated Backing: Minimizes heat loss by preventing conduction through the rear surface.
5. Air Inlet and Outlet: Facilitates continuous airflow, allowing heated air to be directed into the desired space.

The collector works by drawing in cold air from the bottom, which then flows through the heated aluminum cans, increasing in temperature before being expelled through the outlet into a designated area, Picture 2.



Picture 2. *The design and work of the solar air collector*

Based in this drawings, the technical documentation can be created, which can illustrate a straightforward yet effective design, detailing the overall structure, airflow dynamics, and component layout, making them ideal references for easy assembly, Picture 3. They also support the creation of a detailed Bill of Materials (BOM), outlining dimensions, quantities, and cost-effective alternatives to guide low-cost construction.



Picture 3. *Technical documentation for the solar air collector*

This accessible information enables individuals, households, and small communities to source materials and understand the assembly process with minimal effort. Efficiency can be further enhanced by optimizing air circulation and reducing heat loss through proper insulation, making the system both practical and highly effective.

3. **The Construction Process**

The construction of the solar air collector requires readily available materials and basic tools:

- Recycled aluminum cans
- Black, heat-resistant paint
- Wooden or metal frame
- Clear plexiglass or polycarbonate sheet
- Insulating material (e.g., foam board, reflective insulation)
- Drill, saw, and screws
- Fan (optional, for forced airflow)

The process involves preparing the aluminum cans by removing tops and bottoms, cleaning them, and arranging them in vertical stacks. The cans are then painted black to enhance solar absorption.

A rectangular wooden or metal frame is constructed to hold the cans, and insulation is attached to the back panel to minimize heat loss. The painted cans are assembled in columns and secured within the frame before sealing the plexiglass or polycarbonate cover to the front.

Air inlet and outlet vents are installed to facilitate circulation, and the collector is mounted in a sun-exposed area at an optimal tilt angle, Picture 4.

Picture 4. *Construction and installation of the solar air collector*

This simple step-by-step approach ensures that individuals with minimal technical expertise can build and install their own solar collectors. Proper sealing techniques should be applied to ensure maximum efficiency and durability of the system.

4. Environmental and Economic Impact

Using recycled aluminum cans repurposes waste that would otherwise contribute to landfill pollution. This aligns with global sustainability goals and reduces resource consumption [4].

Traditional solar collectors can be expensive, limiting accessibility for low-income households. The DIY solar air collector significantly reduces costs while providing a comparable level of efficiency.

This technology can be adapted for various applications, including residential space heating, greenhouse temperature regulation, and small-scale industrial heating solutions [5].

By promoting community-driven initiatives, this approach fosters local sustainability efforts and self-sufficiency in energy management. Additionally, the widespread adoption of such solutions can reduce dependency on non-renewable energy sources and contribute to a more sustainable energy landscape.

5. Conclusion and Future Perspectives

The repurposing of aluminum cans into solar air collectors presents a promising solution to both energy efficiency and waste management.

This study demonstrates that with minimal resources and technical skills, individuals and communities can harness renewable energy while reducing environmental impact.

Future research should focus on optimizing heat retention and airflow efficiency, developing automated control systems for enhanced performance, and assessing long-term durability and maintenance requirements. Furthermore, testing different materials and configurations could comply improved efficiency.

By embracing sustainable engineering practices, society can move toward a more energy-efficient and environmentally conscious future. Expanding awareness and education on DIY renewable energy systems can further accelerate the adoption of such sustainable solutions.

REFERENCES

[1] IEA (2022), Climate Resilience for Energy Security, OECD Publishing, Paris. https://doi.org/10.1787/2a931f53-en.

[2] Kotyal, K. (2023). Sustainable waste management in the circular Economy: Challenges and opportunities. *Environmental Reports*, 5(2), 1–5. https://doi.org/10.51470/er.2023.5.2.01

[3] Khanlari, A., Tuncer, A. D., Afshari, F., & Sözen, G. (2022). Utilization of recyclable aluminum cans as fins in a vertical solar air heating system: An experimental and numerical study. *Journal of Building Engineering*, 63, 105446. https://doi.org/10.1016/j.jobe.2022.105446

[4] Kishk, S. S., ElGamal, R. A., & ElMasry, G. M. (2018). Effectiveness of recyclable aluminum cans in fabricating an efficient solar collector for drying agricultural products. *Renewable Energy*, 133, 307–316. https://doi.org/10.1016/j.renene.2018.10.028

[5] Yilmaz, A., & Er, A. (2021). Thermal analysis of solar air collectors designed in different types with different flow rates using aluminum cans. *Energy Sources Part a Recovery Utilization and Environmental Effects*, 44(2), 5545–5561. https://doi.org/10.1080/15567036.2021.2006831